

STUDY OF THE RESOURCE USE EFFICIENCY OF FENUGREEK

CROP IN THE STATE OF RAJASTHAN

DEEPA KUMARI KUMAWAT, R. C. KUMAWAT & S. S. JHEEBA

Department of Agricultural Economics, S.K.N. College of Agriculture, Jaipur, Rajasthan, India

ABSTRACT

Rajasthan state is major producer of the fenugreek and this study was aimed to estimate the resource use efficiency of fenugreek crop in the state of Rajasthan. Two regulated markets, Shri-Madhopur mandi (Sikar) and Chomu mandi (Jaipur) were selected. The total number of fenugreek growing farmers in the sample villages was 261 and 354, in Sikar and Jaipur districts, respectively. The cumulative total of fenugreek growing farmers in selected village was 615, from which a sample of 150 farmers was selected on the basis of systematic sampling. The regression coefficient (linear and non-linear), auto-correlation, multicollinearity, autocorrelation, returns to scale were applied on collected data from the selected farmers. Out of seven explanatory variables, only four variables namely; machine labour, seed, irrigation and human labour for Jaipur district and machine labour, seed, fertilizer and human labour for Sikar farms were significant factors influencing gross return. For overall Rajasthan, only five variables machine labour, seed, fertilizer, irrigation and machine labour were significantly affect the gross return. On Jaipur, Sikar and state farms the MVPs of different factor inputs on different size groups positively influenced the gross return. It was taken to mean that all factors were underutilized on Jaipur, Sikar and state farms.

KEYWORDS: Resource Use, Efficiency Fenugreek, Rajasthan

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INTRODUCTION

Judicious use of resources coupled with proper technology plays an important role in stepping up agricultural production. It is generally noticed that the farmers are not using recommended level of farm resources with proper technology. This results in to a gap between the potential yield and the actual yield.

Rajasthan, Gujarat, Uttar Pradesh and Uttaranchal are the major fenugreek producing states of the country which together accounted more than 90 per cent of the total area and total production of fenugreek in the country. Rajasthan is leader in fenugreek production as well as in total area of cultivation of fenugreek. Thus, there is a need to evaluate the resources use efficiency in production of fenugreek on different size-groups of farms in the state.

Although few studies were conducted related to resource use efficiency as follows; Kumawat (1982) concluded that mechanization of irrigation increased the efficiency of labour and improved technology. Anjeneyule *et. al.* (1984) concluded that carious patterns of changes in efficiency use of input (land in acres per farm, human labour in man work days per farm, bullock labour in days per farm, seed in kg per farm, manures and fertilizers in rupees per farm, irrigation charges in rupees per farm) among overall turmeric farm were reflected directly in the ratios of marginal return to opportunity cost and the maximum efficiency in resource use occurs when this ratio is equal to unity. Bahadur (1988) conducted that the cattle labour had its influence on production irrespective of farm

of size.

Singh *et. al.* (1998) was concluded that with the development and adoption of improved technology, both productivity and energy use efficiency per hectare of the crops raised consistently increased. Kale *et. al.* (2005) estimated that there was positive relationship between the size groups and the use of fertilizer ingredients and manure. The MVP-MC ratio for the land variable was greater than unity denoting higher resources use efficiency. The magnitudes of MVP-MC ratio revealed efficient use of most of the resources except fertilizer and other ingredients.

Fernandez and Peter (2009) concluded that the overall technical efficiency of sugarcane farmers in Central Negros was positively related to farmers' age and experience, access to credit, nitrogen fertilizer application, and soil type and farm size. Murugasamy and Veerachamy (2012) analysed the resource use efficiency and total economic efficiency and technical efficiency in various crops and various agricultural regions. Though, the studies fail to incorporate the ideologies of resource use efficiency in the context of head, mid and tail reaches of the canal irrigation.

Thus numbers of studies were conducted related to resource use efficiency of different crops but there was no study was conducted to study resource use efficiency of fenugreek crop in the state of Rajasthan. As Rajasthan state is major producer of the fenugreek and there is still gap in the research. Thus, it was aimed to study the resource use efficiency of fenugreek crop in the state of Rajasthan.

METHODOLOGY

Two districts Sikar and Jaipur were selected randomly for study of cost of cultivation. One regulated market from each of these two districts, Shri-Madhopur mandi (Sikar) and Chomu mandi (Jaipur) were selected on the basis of highest arrivals of fenugreek production during the past three years. Separate lists of all the villages falling within the catchment area of the regulated markets were prepared. Three villages from each of the lists so prepared were randomly selected in proportion.

A list of all the fenugreek growing farmers of the selected villages was prepared from the information provided by the village patwaris. The total number of fenugreek growing farmers in the sample villages was 261 and 354, in Sikar and Jaipur districts, respectively. All the farmers were divided into following five size groups on the basis of size of their land holdings; marginal (less than 1 hectare), small (1-2 hectares), semi-medium (2-4 hectares), medium (4-10 hectares), large (10 hectares and above). The cumulative total of fenugreek growing farmers in selected village was 615, from which a sample of 150 farmers was selected on the basis of systematic sampling. The numbers, thus, obtained were 23 (marginal), 35 (small), 41 (semi-medium), 34 (medium) and 17 (large) farmers of selected village.

Regressions using the ordinary least squares method were run to study factors responsible for gross returns with farmers. Gross return is affected by a large number of factors depending upon the climatic and socio-economic conditions and prices of the crop. However, all the factors cannot be taken into account due to a variety of reasons like non-availability of desired data, multicollinearity among the explanatory variables, problems in their quantification. To get rid of such problems only a few but most probable variables are taken into account. In the present investigation, based on the theoretical a priori reasons, the following variables were selected to study the resource use efficiency: (a) machine labour, (b) seeds, (c) manures, (d) fertilizers, (e) plant protection expenditures, (f) irrigation, and (g) human labour.

Specification of the Regression Model for the Study

The factors affecting gross return of fenugreek crop on the farms in the study area were identified by regressing gross returns on the following explanatory variables (all measured in rupees/ha except human labour which was measured in man days): functional relationship: $Y = f(X_1, X_2, X_3, \dots, X_7)$; where; Y = gross income, X_1 = machine labour, X_2 = seed, X_3 = manures, X_4 = fertilizers, X_5 = plant protection expenditures, X_6 = irrigation, X_7 = human labour. Both linear and log-linear (Cobb-Douglas) forms of the multiple regression function were fitted to the data. Based on the magnitude of R^2 (coefficient of determination) and significance of the estimated regression coefficients multiple log-linear (Cobb-Douglas) relationship was chosen for further study.

The resource use efficiency could be judged based on the MVP (marginal value productivities), which indicates the increase in the gross return from the use of an additional unit of a given input while keeping the level of other inputs constant. The marginal value productivity of the i^{th} input was measured by using the following formula:

$$MVP = b_i \frac{\bar{Y}}{\bar{X}_i};$$

where;

b_i = regression coefficient of i^{th} factor, \bar{Y} = geometric mean of gross returns (in rupees), \bar{X}_i = geometric mean of i^{th} input (in rupees)

Testing the Significance of Regression Coefficients

The reliability of the regression coefficients (b_i) was tested through the student's 't' test of the form:

$$t = \frac{b_i - \hat{b}_i}{SE(\hat{b}_i)};$$

where;

$I = 0, 1, 2, 3 \dots K-1$ (K – being the total number of parameters estimated); t = the variable which follows the 't' distribution with $(n-k)$ degrees of freedom at chosen level of significance; \hat{b}_i = Estimate of the regression parameter (b_i); and $SE(\hat{b}_i)$ = standard error of the estimate (b_i). For testing the reliability of b_i , it was hypothesized that there was no linear/log-linear relationship between the explanatory variable X_i and the dependent variable Y ; i.e., $b_i = 0$; symbolically it was denoted as $H_0 : b_i = 0$.

To decide about the acceptance or rejection of null hypothesis, $H_0 : b_i = 0$, vis-à-vis alternative hypothesis, $H_A : b_i \neq 0$, the calculated value of 't' was compared with the table value of 't' for $(n-k)$ degrees of freedom at α ($\alpha = 1\%, 5\%$ and 10%) level of significance which defined critical region for a two tailed test (a test in which the critical region lies on both the tails of the distribution curve, half area lying on each tail for a test of α level of significance). The decision in regard to acceptance or rejection of the null hypothesis ($H_0 : b_i = 0$) was made as follows:

- When the absolute value of the calculated 't' was higher than the theoretical (tabulated) value of 't'; i.e., $|t| > t$, the null hypothesis was rejected.

- When $|t| < t$, the null hypothesis was not rejected in favor of the alternative hypothesis. In other words the b_i was not considered statistically significant at chosen level of significance.

Multicollinearity

To test the presence of multicollinearity (high degree of correlation among the explanatory variables), simple correlation matrices as well as variance inflation factor (VIF) were worked out. For testing multicollinearity on the basis of correlation coefficients, Klein's (1962) observation was taken into consideration that the effect of multicollinearity was tolerable if the correlation between any pair of independent variables (r_{ij}) included in the model did not exceed in magnitude to the multiple correlation coefficient I , that is, $|r_{ij}| < |R|$. Where r_{ij} is the simple correlation coefficient between i^{th} and j^{th} variables.

For understanding working out procedure for VIF, consider the following linear model with k independent variables: $Y = b_0 + b_1 X_1 + b_2 X_2 + b_j X_j + \dots + b_k X_k + e$.

The standard error of the estimate of b_j is $\sigma (X'X)^{-1}_{j+1, j+1}$, where X is regression design matrix – a matrix such that $X_{i,j+1}$ is the value of the j^{th} covariate for the i^{th} case or observation, and $X_{i,1}$ equals 1 for all i . It turns out that this variance can be equivalently expressed as:

$$Var(\hat{b}_i) = \frac{\sigma^2}{(n-1)Var(\hat{X}_i)} \frac{1}{1-R_i^2};$$

where;

R_j^2 = multiple R^2 for the regression of X_j on the other covariates (a regression that does not involve the response variable Y). This identity separates the influences of several distinct factors on the variance of the coefficient estimate. σ^2 = scatter in the data around the regression surface; n = sample size; $Var(\hat{X}_i)$ = variability in the covariates; the remaining term, $1 / (1 - R_j^2)$ is the VIF. K number of VIFs (equal to the number of explanatory variables) were calculated, one for each X_i by first running an ordinary least square regression that had X_i as a function of all the other explanatory variables in the first equation. If $i = 1$, for example, the equation would be: $X_1 = \alpha_2 X_2 + \alpha_3 X_3 + \dots + \alpha_k X_k + C_0 + e$; Where c_0 is a constant and e is the error term. Then, VIF factor for b_i was calculated with the following formula:

$$Var(\hat{b}_i) = \frac{1}{1-R_i^2};$$

where R_i^2 is the coefficient of determination of the regression equation in step one. To analyze magnitude of multicollinearity by considering the size of the VIF (b_i), a common rule of thumb followed was that if $VIF(b_i) > 10$ then, it was taken to mean high multicollinearity (Kutner, 2004).

Autocorrelation

The term autocorrelation is defined as “correlation between members of series of observations ordered in time (as in time series data) or space (as in cross sectional data)”. In the regression context the classical linear regression model assumes that such autocorrelation does not exist in the disturbances U_i . Symbolically, $E(U_i U_j) = 0$ $i \neq j$. Violation of this assumption leads to the problem of autocorrelation. Specification bias resulting from excluding some relevant variables from the model or using an incorrect functional form may lead to (spatial) autocorrelation in the cross sectional data.

Although the OLS estimates remain unbiased as well as consistent in the presence of autocorrelation, they are no longer efficient. As a result, the usual 't' and 'F' tests of significance cannot be applied legitimately. Hence remedial measures are needed depending upon the nature of interdependence among the disturbances U_i (William and Kendall, 1971). In the present investigation Durbin-Watson test was used to test the autocorrelation between the residuals. For testing autocorrelation Durbin – Watson 'd' statistic was calculated as follows:

$$d = \frac{\sum_{t=2}^n (e_t - e_{t-1})^2}{\sum_{t=1}^n e_t^2};$$

where;

e_t are sample residuals. The test for autocorrelation was conducted as follows: $H_0 : \rho = 0$; $H_A : \rho > 0$ (Positive autocorrelation); if ' d ' < d_L rejected H_0 in favor of positive autocorrelation; if $d_L < 'd' < d_U$ inconclusive; if $d_U < 'd'$ did not reject H_0 ; $H_0 : \rho = 0$; $H_A : \rho < 0$ (Negative auto-correlation); If ' d ' < $4 - d_U$ did not reject H_0 ; if $(4 - d_U) < 'd' < (4 - d_L)$ inconclusive; if $(4 - d_L) < 'd'$ rejected H_0 in favor of negative autocorrelation; where; H_0 = Null hypothesis; H_A = alternative hypothesis; ρ = autocorrelation coefficient; d = Durbin – Watson statistic; d_L = lower limit for critical value; d_U = Upper limit for critical value. Finally, the region in which the estimated value of ' d ' lay was located and the inference was drawn in a manner as stated above.

Return to Scale

The some of elasticity coefficients (Σb_i) indicate the returns to scale and the statistical test for the significant difference of the value of coefficient from unity is given as:

$$F_{(1, N-K)} = \left[\left(\sum b_i - 1 \right)^2 / 1 \right] / \left[\left(\sum_{i=1}^k \text{var } b_i \right) / (N - K) \right];$$

where,

N = sample size, K = number of exogenous variables.

RESULTS AND DISCUSSIONS

One hundred fifty farmers were selected from two districts i.e. Jaipur and Sikar in the ratio of 58:42, respectively (Table 1). Out of these maximum (27.33 per cent) farmers belonged to semi-medium group followed by small (23.34 per cent), medium (22.67 per cent), marginal (15.33 per cent) and large (11.33 per cent) groups. In Jaipur district, maximum per cent was of small farmers (25.29 per cent); while in Sikar district the maximum per cent (31.75) was of semi-medium farmer.

Table 1: Category-Wise Distribution of Selected Farmers in the Study Area

Selected District	Category of Farmers					Overall
	Marginal	Small	Semi-Medium	Medium	Large	
Jaipur	14 (16.09)	22 (25.29)	21 (24.14)	20 (22.99)	10 (11.49)	87 (100)
Sikar	9 (14.29)	13 (20.63)	20 (31.75)	14 (22.22)	7 (11.11)	63 (100)

Table 1: Contd.,						
Total No. of Selected Farmers	23 (15.33)	35 (23.34)	41 (27.33)	34 (22.67)	17 (11.33)	150 (100)

Figures in parentheses are the per cent by the overall

Regression Analysis

For analysing resource use efficiency in fenugreek crop on different size groups of farmers of Jaipur and Sikar districts, multiple regression functions were estimated by taking gross return as the dependent variable (Y) and machine labour (X_1), seed (X_2), manure (X_3), fertilizers (X_4), plant protection measures (X_5), irrigation (X_6) and human labour (X_7), as the independent variables. Both linear and log-linear (Cobb-Douglas) forms of production relationships were estimated using the ordinary least squares (OLS) technique. Overall analysis was also attempted to identify the causal factors of gross return in the study area at the aggregate level. Based on the value of R^2 and 't' test (*i.e.*, standard errors of the regression coefficients) the Cobb-Douglas production function was used due to higher value of coefficient of multiple determination obtained and preferred because of the computational ease and theoretical fitness to agriculture data.

The possibility of autocorrelation among the estimated residuals was also tested with the help of Durbin-Watson test. For deciding on the presence of multicollinearity as well as the best set of explanatory variables for the regression model, the stepwise regression method (stepwise forward regression) was followed. In this method one variable at a time was included in the model. The decision to add a variable was made on the basis of the contribution of that variable to the error sum of squares as judged by the F-test.

Jaipur District

The overall regression results for farmers of Jaipur district revealed (Table 2) that only four explanatory variables namely; machine labour (X_1), irrigation (X_6), human labour (X_7) and seed (X_2) significantly affected the gross return (Table 2). The results of VIF indicated that there was no multicollinearity problem among these variables. The estimated value of Durbin -Watson 'd' statistic (1.702) lay within the bounds of $du < 1.702 < 4 - du$, *i.e.*, $1.630 < 1.702 < 2.263$ indicating no autocorrelation (positive or negative) among the estimated residuals at 1 per cent level of significance corresponding to $n = 82$ and $k = 4$. The regression coefficients for machine labour ($X_1 = 0.467$), irrigation ($X_6 = 0.200$) and human labour ($X_7 = 0.182$) and seed ($X_2 = 0.137$) had significant influence on the amount of gross return. The results indicated that the effect machine labour, irrigation, human labour and seed were positive and significant at 1 per cent level of significance.

Table 2: Estimated Cobb-Douglas Production Function for Overall Farmers of Jaipur District Dependent Variable (Y) = Gross Return Number of Farmers (N) = 87

S. No.	Explanatory Variable	Regression Coefficient	Standard Error	VIF	Elasticity Coefficient
1	Intercept (a)	1.584	0.083	-	-
2	Machine labour (X_1)	0.467***	0.044	3.660	0.467
3	Irrigation (X_6)	0.200***	0.039	4.516	0.200
4	Human labour (X_7)	0.182***	0.041	9.077	0.182
5	Seed (X_2)	0.137***	0.037	8.752	0.137

*** Significant at 1 per cent level of significance

The coefficient of multiple determinations (R^2) was 0.987 indicating that 98.70 per cent of variation in gross return was explained by the explanatory variables included in the model. The observed F-value (161.18) for R was higher than the tabulated F value with (4, 82) degrees of freedom indicating regression to be significant. The elasticity coefficients of gross return with respect to all the selected explanatory variables were estimated to be 0.467, 0.200, 0.182 and 0.137 for machine labour, irrigation, human labour and seed, respectively. This indicated that 1 per cent increase in expenditure on machine labour, irrigation, human labour and seed increased the gross return by 0.467, 0.200, 0.182 and 0.137 per cent, respectively. This was taken to mean that the gross return was inelastic to change in machine labour, irrigation, human labour and seed. The sum of elasticity coefficients, *i.e.*, returns to scale of production on overall basis Jaipur farms was 0.984 implying decreasing returns to scale.

Sikar District

The regression results for overall farmers of Sikar district revealed (Table 3) that only four explanatory variables namely; machine labour (X_1), seed (X_2), fertilizer (X_4) and human labour (X_7) significantly affected the gross return (Table 3). The results of VIF indicated that there was no multicollinearity problem among these variables. The estimated 'd' statistic indicated no autocorrelation (positive or negative) among the estimated residuals. The regression coefficients for machine labour ($X_1 = 0.369$), seed ($X_2 = 0.283$), fertilizer ($X_4 = 0.270$) were significantly positive at one per cent level of significance and human labour ($X_7 = 0.063$) was significantly positive at 5 per cent level of significance. The coefficient of multiple determination (R^2) was 0.989 indicating that 98.90 per cent of variation in gross return was explained by the explanatory variables included in the model. The observed F-value was higher than the tabulated F value indicating regression to be significant.

The elasticity coefficients for gross return with respect to ; machine labour (X_1), seed (X_2), fertilizer (X_4) and human labour (X_7) were estimated to be 0.369, 0.283, 0.270 and 0.063 respectively. This indicated that one per cent increase on machine labour, seed, fertilizer and human labour increased the gross return by 0.369, 0.283, 0.270 and 0.063 per cent, respectively. This was taken to mean that the gross return was inelastic to change in machine labour, seed, fertilizer and human labour. The sum of elasticity coefficients, *i.e.*, returns to scale of production was 0.985 on overall farms implying decreasing returns to scale.

Table 3: Estimated Cobb-Douglas Production Function for Overall Farmers of Sikar District Dependent Variable (Y) = Gross Return Number of Farmers (N) = 63

S. No.	Explanatory Variable	Regression Coefficient	Standard Error	VIF	Elasticity Coefficient
1	Intercept (a)	1.476	0.092	-	-
2	Machine labour (X_1)	0.369***	0.058	6.875	0.369
3	Seed (X_2)	0.283***	0.049	4.284	0.283
4	Fertilizer (X_4)	0.270***	0.053	6.967	0.270
5	Human labour (X_7)	0.063**	0.031	5.557	0.063

*** Significant at 1 per cent level of significance;

** 5 per cent level of significance

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Marginal Farmers

The values of VIF for these explanatory variables ranged for 1.462 to 4.588 indicating no multicollinearity problem among them. The estimated 'd' value indicated no autocorrelation (neither positive nor negative) among the

estimated residuals at 1 per cent level of significance. The effect of manure ($X_3 = 0.497$) and seed ($X_2 = 0.438$) significant at one per cent level of significance. These two explanatory variables together accounted for 96.50 per cent variation in the gross return. The observed F-value for R was higher than the tabulated F value indicating regression to be significant. The elasticity coefficients for gross returns with respect to both explanatory variables were estimated to be 0.497 and 0.438 for manure and seed, respectively. This indicated that one per cent increase in human labour led to increase in the gross return by 0.497 per cent and manures by 0.438 per cent implying that gross return was relatively inelastic to the changes in amount of seed and manures. Returns to scale of production for marginal farmers was estimated to be 0.935 implying decreasing returns to scale.

Small Farmers

Machine labour (X_1), human labour (X_7) and fertilizer (X_4) significantly affected the gross return on the small farms. The results show that there were no problems of multicollinearity and autocorrelation among these variables. The regression coefficients for machine labour ($X_1 = 0.394$), human labour ($X_7 = 0.306$) and fertilizer ($X_4 = 0.218$) were significantly positive at one per cent level of significance. These variables together explained 97.00 per cent variation in gross returns. The observed F-value was higher than the tabulated F value indicating regression to be significant. The elasticity coefficient for gross return with respect to the explanatory variables, *i.e.*, machine labour, human labour and irrigation were estimated to be 0.394, 0.306 and 0.218, respectively. This indicated that one per cent increase in expenditure increased the gross return by 0.394 per cent, 0.306 per cent and 0.218 per cent, respectively. Returns to scale of production on small farms was 0.918 implying decreasing returns to scale.

Semi-Medium Farmers

Machine labour (X_1), irrigation (X_6) and seed (X_2) significantly affected the gross return on semi-medium farms. The regression coefficients for machine labour ($X_1 = 0.325$), irrigation ($X_5 = 0.409$) and seed ($X_2 = 0.223$) were significantly positive at one per cent level of significance. These variables together explained 97.40 per cent of the variation in gross return. The observed F-value was higher than the tabulated F value indicating regression to be significant. The elasticity coefficients for gross returns were estimated to be 0.325, 0.409 and 0.223 for machine labour, irrigation and seed respectively indicating that one per cent increase in expenditure increased the gross return by 0.325 per cent, 0.409 per cent and 0.223 per cent, respectively. This implied that gross return was relatively inelastic to the changes in irrigation, machine labour and seed. The sum of elasticity coefficients, *i.e.*, returns to scale of production on these farms was 0.957 implying decreasing returns to scale.

Medium Farmers

In case of medium farmers fertilizer ($X_4 = 0.510$), irrigation ($X_6 = 0.358$) and plant protection measure ($X_5 = 0.069$) were found to be statistically significant. The regression coefficients for fertilizer, irrigation and plant protection measure were significantly positive at one per cent level of significance. These variables together accounted for 97.20 per cent of the total variation in the gross return. The elasticity coefficients for gross return with respect to the selected explanatory variables, *i.e.*, fertilizer, irrigation and plant protection measure were estimated to be 0.510, 0.358 and 0.069. This implied that gross return was inelastic to the changes in expenditure on fertilizer, irrigation and plant protection measure. The sum total of elasticity coefficients was worked out to be 0.937 implying decreasing returns to scale on such farmers.

Large Farmers

On large farms machine labour (X_1) and plant protection measure (X_5) significantly affected the gross return. The values of VIF (variance inflation factor) for the two selected explanatory variables were estimated to be less than ten indicating no multicollinearity problem among these variables. The Durbin–Watson test also indicated no autocorrelation (neither positive nor negative) among the estimated residuals. The regression results revealed that the coefficient of machine labour ($X_1 = 0.464$) and plant protection measure ($X_5 = 0.420$) were significant at one per cent level of significance. These explanatory variables together accounted for 97.50 per cent variation in the gross return. The observed F-value was higher than the tabulated F value indicating regression to be significant. The elasticity coefficients of gross return with respect to both the explanatory variables indicated that one per cent increase in expenditure on machine labour and plant protection measure increased the gross return by 0.464 per cent and 0.420 per cent, respectively indicating the gross return to be relatively inelastic to the change in machine labour and plant protection measure. The returns to scale of production on large farms were 0.884 implying decreasing returns to scale.

Overall Farmers

The regression results for overall farmers of state of Rajasthan revealed that only five explanatory variables namely; machine labour (X_1), seed (X_2), fertilizer (X_4), irrigation (X_6), and human labour (X_7) significantly affected the gross return. The results of VIF indicated that there was no multicollinearity problem among these variables. The estimated 'd' statistic indicated no autocorrelation (positive or negative) among the estimated residuals. The regression coefficients for machine labour ($X_1 = 0.343$), seed ($X_2 = 0.203$), fertilizer ($X_4 = 0.213$), irrigation ($X_6 = 0.125$) and human labour ($X_7 = 0.056$) were significantly positive at one per cent level of significance. The coefficient of multiple determination (R^2) was 0.987 indicating that 98.70 per cent of variation in gross return was explained by the explanatory variables included in the model. The observed F-value was higher than the tabulated F value indicating regression to be significant. The elasticity coefficients for gross return with respect to ; machine labour (X_1), seed (X_2), fertilizer (X_4), irrigation (X_6) and human labour (X_7) were estimated to be 0.343, 0.203, 0.213, 0.125 and 0.056 respectively. Thus, gross return was inelastic to change in machine labour, seed, fertilizer irrigation and human labour. The sum of elasticity coefficients, *i.e.*, returns to scale of production was 0.940 on overall farms implying decreasing returns to scale.

Jaipur vs. Sikar and State of Rajasthan

Out of seven explanatory variables, only four variables namely; machine labour (X_1), seed (X_2), irrigation (X_6) and human labour (X_7) for Jaipur district and machine labour (X_1), seed (X_2), fertilizer (X_4) and human labour (X_7) for Sikar farms were significant factors influencing gross return. Though, their effect was not the same across the categories of Jaipur and Sikar farms. It varied from category to category. In case of marginal farms of both Jaipur and Sikar districts it was seed and manure that influenced the gross return positively and significantly. In case of small of farms of Jaipur district, machine labour, human labour and fertilizer and in case of Sikar farms human labour, irrigation and fertilizer had positive influence on the gross return. This indicates that human labour, machine labour, seed, irrigation, fertilizer and manure led to increases in gross return on marginal and small farms in the study area.

In case of semi-medium farms of Jaipur district, irrigation, machine labour and fertilizer and for Sikar farms, irrigation, machine labour and plant protection measures influenced the gross return positively and significantly. In case of medium farms of Jaipur and districts, irrigation, machine labour and fertilizer positively and significantly affected the gross

return. In case of large farms of Jaipur district these were machine labour and fertilizer expenses and for Sikar farms machine labour and irrigation expenses that influenced the gross return positively and significantly. At aggregate level human labour, machine labour, seed, fertilizer, and irrigation had significantly positive effect on the quantum of gross return of the Jaipur as well as Sikar farms.

A look into factor-wise influence revealed that human labour positively and significantly influenced the gross return on overall categories of Jaipur and Sikar farms. Machine labour had significantly positive effect on the gross return of small, semi-medium, medium, large and overall size group of Jaipur farms and Sikar farms. Seed; too, had significantly positive effect on the gross return of marginal and overall categories of Jaipur farm and Sikar farms.

Manure significantly and positively influenced gross return of marginal farms of Jaipur and Sikar farms. Fertilizer positively and significantly influenced the gross return on small, semi-medium, medium and large categories of Jaipur and on small, medium and overall categories of Sikar farms. Plant protection positively significantly on semi-medium farm of Sikar influenced the gross return. Irrigation positively and significantly influenced the gross return of semi-medium, medium and overall category of Jaipur farms and small, semi-medium, medium and large category of Sikar farmers. Human labour significantly and positively influenced gross return of small or over all group of farms of Jaipur and Sikar farms.

For overall Rajasthan, only five variables machine labour, seed, fertilizer, irrigation and machine labour were significantly affect the gross return. On marginal farms manure and seed; for small farms machine labour, human labour and fertilizer; for semi-medium machine labour, seed, and irrigation; for medium farms fertilizer, irrigation and plant protection measure; for large farms machine labour and plant protection measure; overall farms machine labour, seed, fertilizer, irrigation and human labour were significantly affect the gross return.

Factor wise influence revealed that first machine labour was significant on small, semi-medium and overall farms; second seed was significant on marginal, semi-medium and overall farms; third manure was significant on marginal farms; fourth fertilizer was significant on small, medium and overall farms; fifth plant protection measure was significant on medium and large farms; sixth irrigation was significant on semi-medium, medium and overall farms and last one human labour was significant at small and overall farms of Rajasthan.

Marginal Value Productivity, Factor Costs and Economic Efficiency

In order to enable comparison of the absolute output response per unit of factor input, it is necessary to compute the marginal value productivity of each factor input. The marginal value productivity (MVP) of input was estimated by taking partial derivatives of return with respect to input concerned at the geometric mean level of inputs. The regression coefficient (elasticity coefficient) of an explanatory variable indicates the per cent change in gross farm output associated with one per cent change in factor input. An input factor is considered to be most efficient if its marginal value product is just sufficient to off-set its cost. Equality of marginal value product to factor cost is the basic condition that must be satisfied to obtain efficient resource use. The ratio of marginal returns to acquisition costs *i.e.*, economic efficiency for all variables were calculated by dividing the marginal value productivities by the marginal factor costs. The marginal factor cost (MFC) was assumed to be constant, *i.e.* 1 unit for each input.

MVPs: Jaipur District

The average period of operating expenses was taken as three months during which funds were tied up in a crop. Taking 7 per cent interest rate per annum on short term loans, the interest charge on variable expenses investment was 1.75 (3.5/2) per cent. After deducting this 1.75 per cent interest cost, the values of marginal value productivity were obtained.

The table indicates that marginal value productivities of factor costs were more than one, varying from ₹ 3.06 for machine labour (small farms) to ₹ 437.52 for human labour (small farms). The MVP for machine labour (X_1) was ₹ 3.06, 3.09, 3.24, and 4.46 on small, semi-medium, medium and large farmers, respectively with an overall average of ₹ 3.65. It shows that an increase of one unit in variable factor would be accompanied by an increase in the gross income of ₹ 3.06, 3.09, 3.24, and 4.46 on small, semi-medium, medium and large farmers, respectively, holding other inputs constant at their respective geometric mean levels. The MVP for seed was ₹ 25.44 for marginal and ₹ 4.85 for overall categories of farms.

Table 4: Marginal Value Productivities (MVP) of Different Input of Farmers for Fenugreek Production in Jaipur District

Variables	Category of Farmers					
	Marginal	Small	Semi-Medium	Medium	Large	Overall
Machine labour (X_1)	-	3.06 (3.01)	3.09 (3.03)	3.24 (3.19)	4.46 (4.36)	3.65 (3.59)
Seeds (X_2)	25.44 (25.00)	-	-	-	-	4.85 (4.76)
Manure(X_3)	9.20 (9.04)	-	-	-	-	-
Fertilizer (X_4)	-	11.16 (10.97)	18.01 (17.70)	13.54 (13.31)	15.83 (15.56)	-
Plant protection (X_5)	-	-	-	-	-	-
Irrigation (X_6)	-	-	9.32 (9.16)	15.72 (15.45)	-	8.63 (8.49)
Human labour (X_7)	-	437.52 (429.99)	-	-	-	323.44 (317.88)

(The marginal factor cost was assumed to be constant i.e. 1 for each input; Figures in parentheses are the ratio of marginal returns to acquisition costs adjusted for time value of money)

In case of manure (X_3) the gross marginal value productivity was ₹ 9.20 and net MVP was ₹ 8.20 on marginal farmers. In case of remaining categories it was not significant. The gross marginal value productivity of fertilizer input (X_4) per rupee investment was ₹ 11.16 on small, ₹ 18.01 on semi medium, ₹ 13.54 on medium and ₹ 15.87 on large categories of farms. The marginal value productivity of plant protection measures (X_5) was non-significant for all categories of farms. The MVP of irrigation (X_6) per rupee investment was ₹ 9.32, 15.72 and 8.63 on semi-medium, medium and overall size groups of farms, respectively. The net MVP was ₹ 8.32, 14.72 and 7.63 for semi-medium, medium and over all farm size groups. Among all the variable factors the MVP of human labour was noted to be the highest. The gross marginal value productivity was ₹ 437.52 and 323.44 on small and over all farm size, respectively. This shows that an additional unit spending of man days on human labour gives a net profit of ₹ 237.52 and 123.44 on small and overall size group of farms in Jaipur district.

MVPs: Sikar District

Marginal value productivities of factor costs were more than one, varying from ₹ 1.73 for plant protection measures (semi-medium farms) to ₹ 716.37 for human labour (small farms). The gross marginal value productivity of

machine labour (X_1) on semi-medium, medium, large and overall categories of farms were ₹ 2.24, 3.04, 5.49 and 2.83, respectively as assuming MFC of human labour to be constant at ₹ 1.00. The net profit was ₹ 1.24, 2.04, 4.49 and 1.83 on semi-medium, medium, large and overall categories of farms, respectively by holding other inputs constant at their respective geometric mean levels.

The (gross) marginal value productivity of seed (X_2) was ₹ 11.26 and 10.77 on marginal and overall size group, respectively. This shows that additional spending of one rupee on seed gives us a net profit of ₹ 10.26 and 9.77. In case of manure (X_3) the (gross) marginal value productivity was ₹ 15.87 and net MVP was ₹ 14.87 on marginal farmers. The gross marginal value productivity per rupee investment on fertilizer (X_4) was ₹ 10.91 for small, 7.57 for medium and 13.20 for overall categories and net MVP ₹ 9.91, 6.57 and 12.20 for small, medium and overall categories of farms, respectively.

The gross MVP of plant protection measures (X_5) was ₹ 1.73 for semi-medium farms and the net marginal variable productivity ₹ 0.73. The marginal value productivity of irrigation (X_6) per rupee investment was ₹ 11.38, 25.30, 22.49 and 11.75 for small, semi-medium, medium and large size groups of farms, respectively. The gross MVP (return per unit i.e. man days) of human labour (X_7) was ₹ 716.37 and 113.09 for small and overall farms, respectively.

Table 5: Marginal Value Productivities (MVP) of Different Input of Farmers for Fenugreek Production in Sikar District

Variables	Category of Farmers					
	Marginal	Small	Semi-Medium	Medium	Large	Overall
Machine labour (X_1)	-	-	2.24 (2.21)	3.04 (2.99)	5.49 (5.40)	2.83 (2.79)
Seeds (X_2)	11.26 (11.06)	-	-	-	-	10.77 (10.59)
Manure(X_3)	15.87 (15.60)	-	-	-	-	-
Fertilizer (X_4)	-	10.91 (10.71)	-	7.57 (7.44)	-	13.20 (12.97)
Plant protection (X_5)	-	-	1.73 (1.69)	-	-	-
Irrigation (X_6)	-	11.38 (11.18)	25.30 (24.87)	22.49 (22.11)	11.75 (11.54)	-
Human labour (X_7)	-	716.37 (704.05)	-	-	-	113.09 (111.05)

(The marginal factor cost was assumed to be constant i.e. 1 for each input; Figures in parentheses are the ratio of marginal returns to acquisition costs adjusted for time value of money)

MVPs: State of Rajasthan

The estimated ratios of marginal value productivities (MVPs) to different factor costs affecting the crop yield in state of Rajasthan are presented in table 6. The table indicates that marginal value productivities of factor costs were more than one, varying from ₹ 2.45 for machine labour (semi-medium farms) to ₹ 490.07 for human labour (small farms). The MVP for machine labour (X_1) was ₹ 2.90, 2.45 and 3.88 on small, semi-medium and large farmers, respectively with an overall average of ₹ 3.44. It shows that an increase of one unit in variable factor would be accompanied by an increase in the gross income of ₹ 2.90, 2.45 and 3.88 on small, semi-medium and large farmers, respectively, holding other inputs constant at their respective geometric mean levels.

Table 6: Marginal Value Productivities (MVP) of Different Input of Farmers for Fenugreek Production in State of Rajasthan

Variables	Category of Farmers					
	Marginal	Small	Semi-Medium	Medium	Large	Overall
Machine labour (X ₁)	-	2.90 (2.85)	2.45 (2.41)	-	3.88 (3.81)	3.44 (3.38)
Seeds (X ₂)	17.60 (17.30)	-	8.26 (8.12)	-	-	7.40 (7.28)
Manure(X ₃)	10.37 (10.19)	-	-	-	-	-
Fertilizer (X ₄)	-	11.25 (11.05)	-	24.46 (24.04)	-	7.09 (6.97)
Plant protection (X ₅)	-	-	-	5.88 (5.78)	24.59 (24.16)	-
Irrigation (X ₆)	-	-	17.68 (17.38)	18.50 (118.18)	-	5.32 (5.22)
Human labour (X ₇)	-	490.07 (481.64)	-	-	-	153.48 (150.84)

(The marginal factor cost was assumed to be constant i.e. 1 for each input; figures in parentheses are the ratio of marginal returns to acquisition costs adjusted for time value of money)

The MVP for seed was ₹ 17.60 for marginal, ₹ 8.26 for semi-medium and ₹ 7.40 for overall categories of farms. In case of manure (X₃) the gross marginal value productivity was ₹ 10.37 and net MVP was ₹ 9.37 on marginal farmers. In case of remaining categories it was not significant. The gross marginal value productivity of fertilizer input (X₄) per rupee investment was ₹ 11.25 on small and ₹ 24.56 on medium categories of farms.

The marginal value productivity of plant protection measures (X₅) was 5.88 on medium and 24.59 on large categories of farms. The MVP of irrigation (X₆) per rupee investment was ₹ 17.68, 18.50 and 5.32 on semi-medium, medium and overall size groups of farms, respectively. The net MVP was ₹ 16.68, 17.50 and 4.32 for semi-medium, medium and over all farm size groups. Among all the variable factors the MVP of human labour was noted to be the highest. The gross marginal value productivity was ₹ 490.07 and 153.48 on small and over all farm size, respectively. This shows that an additional unit spending of man days on human labour gives a net profit of ₹ 390.07 on small and for overall size group it was not profitable.

MVPs: Jaipur vs. Sikar and State of Rajasthan

From the above discussion, it may be concluded that the marginal value productivities on different size groups were positively influenced factor inputs on Jaipur, Sikar districts and state as a whole. The MVP analysis suggested a significant scope for raising crop productivity by adjustment/reallocation of important farm inputs on both the districts and state as a whole. This would lead to enhance production and productivity of fenugreek crop in Jaipur, Sikar districts and state of Rajasthan.

These results indicated a need to create awareness among the farmers through extension services. Institutional support was also required to improve the access of fenugreek producing farmers to input marketing and credit institutions.

CONCLUSIONS

Out of seven explanatory variables, only four variables namely; machine labour (X₁), seed (X₂), irrigation (X₆) and human labour (X₇) for Jaipur district and machine labour (X₁), seed (X₂), fertilizer (X₄) and human labour (X₇) for

Sikar farms were significant factors influencing gross return. Though, their effect was not the same across the categories of Jaipur and Sikar farms, which varied from category to category.

In case of marginal Jaipur and Sikar farms, it was seed and manure that influenced the gross return positively and significantly. In case of small farms; machine labour, fertilizer and human labour on Jaipur farms and fertilizer, human labour and irrigation on Sikar farms had positive influence on the gross return. This indicates that human labour, machine labour, seed, manure, fertilizer and irrigation led to increase in gross return on marginal and small farms in the study area. In case of semi-medium farms; machine labour, fertilizer and irrigation on Jaipur farms and machine labour, plant protection measure and irrigation on Sikar farms that influenced the gross return positively and significantly.

In case of medium Jaipur farms, machine labour, fertilizer and irrigation and on Sikar farms machine labour, fertilizer and irrigation positively and significantly affected the gross return. In case of large Jaipur farmers these were machine labour and fertilizer and on Sikar farms machine labour and irrigation that influenced the gross return positively and significantly. At aggregate level machine labour, seed, fertilizer, irrigation and human labour had significantly positive effect on the quantum on gross return of the Jaipur as well as Sikar farms.

For overall Rajasthan, only five variables machine labour, seed, fertilizer, irrigation and machine labour were significantly affect the gross return. On Jaipur, Sikar and state farms the MVPs of different factor inputs on different size groups positively influenced the gross return. It was taken to mean that all factors were underutilized on Jaipur, Sikar and state farms.

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